

Doc 7192
AN/857



Training Manual

Part D-1
Aircraft Maintenance
(Technician/Engineer/Mechanic)

Approved by the Secretary General
and published under his authority

Second Edition — 2003

International Civil Aviation Organization

AVA Documents
Document Sharing Hub

Doc 7192
AN/857



Training Manual

Part D-1 **Aircraft Maintenance** **(Technician/Engineer/Mechanic)**

Approved by the Secretary General
and published under his authority

Second Edition — 2003

International Civil Aviation Organization

AVA **Documents**
Document Sharing Hub

AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly *Supplement to the Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

[illegible][illegible]
$$(ii)$$

FOREWORD

Aircraft maintenance personnel can have varying degrees of educational background; they can range from the self-taught individual to the holder of a university engineering degree. However, irrespective of educational background, all aircraft maintenance personnel must undergo a very comprehensive technical training that provides the necessary knowledge, skills and attitudes for assuming responsibility over the maintenance of aircraft.

This manual has been prepared by the Personnel Licensing and Training Section of ICAO and replaces Doc 7192 — *Training Manual*, Part D-1 — *Aircraft Maintenance Technician* (First Edition, 1976). ICAO would like to acknowledge the contribution received from the Aircraft Maintenance Engineers Licensing Study Group and individual experts who have provided support, advice and input.

Toward this end, Doc 7192 — *Training Manual*, Part D-1 — *Aircraft Maintenance (Technician/Engineer/Mechanic)* (Second Edition, 2003) details the training requirements which, however, are not all-inclusive and are provided as a guideline for the minimum requirements used in the training of Aircraft Maintenance (Technician/Engineer/Mechanic) (AME) or personnel. The training course for maintenance personnel assigned to duties in line with the requirements of Annex 1 — *Personnel Licensing* and Annex 6 — *Operation of Aircraft* must include but should not be limited to the syllabi suggested in this manual.

This second edition differs considerably from the first edition of Doc 7192, Part D-1. It contains training syllabi for AMEs that cover both knowledge and skill requirements outlined in Annex 1. New subject matter has been included for the first time on topics such as airships, composite materials and Human Factors. Material that addressed the management and staffing of a training school

has however been removed as this aspect is now contained in the *Manual on Establishment and Operation of Aviation Training Centres* (Doc 9401).

The format of the manual reflects the concept of competency-based training and is now consistent with other manuals in the Doc 7192 series. Subject matter that must be addressed during the three phases of training is indicated in 1.5 — Training reference guide and the associated Appendix 1 to Chapter 1, which outlines the approximate duration of the course and the level of expertise required in each subject.

Throughout this manual, the use of the male gender should be understood to include male and female persons. References to Annex 1 take into account all amendments up to and including Amendment 162.

Furthermore, with respect to the phrase “Aircraft Maintenance (Technician/Engineer/Mechanic),” the terms in brackets are given as acceptable additions to the title of the Licence. Each Contracting State is expected to use in its own regulations the one it prefers. For the purpose of this manual and as a matter of convenience, the acronym AME will be used to refer to Aircraft Maintenance (Technician/Engineer/Mechanic).

Comments on this manual, particularly with respect to its application, usefulness and scope of coverage, would be appreciated from States and ICAO Technical Co-operation Field Missions. These will be taken into consideration in the preparation of subsequent editions. Comments concerning this manual should be addressed to:

The Secretary General
International Civil Aviation Organization
999 University Street
Montréal, Quebec H3C 5H7
Canada

TABLE OF CONTENTS

	<i>Page</i>		<i>Page</i>
Introduction.....	(vii)	4.4 Physics	4-2
Acronyms and abbreviations.....	(ix)	4.5 Technical drawing	4-4
Chapter 1. Training principles.....	1-1	4.6 Chemistry.....	4-5
1.1 Regulatory requirements	1-1	4.7 Fixed wing aerodynamics and flight control	4-5
1.2 Training requirements	1-1	4.8 Rotary wings aerodynamics and flight control	4-6
1.3 Types of training	1-2	Chapter 5. Aircraft engineering and maintenance: Airframes.....	5-1
1.4 Standard of accomplishment	1-5	5.1 Introduction	5-1
1.5 Training reference guide	1-5	5.2 Training objectives	5-1
1.6 Training objectives.....	1-6	5.3 Maintenance practices and materials: Airframe/Powerplant	5-1
Appendix 1 to Chapter 1. Recommended licence categorization and limitations	1-7	5.4 Aircraft systems and structures: Fixed wing.....	5-5
Appendix 2 to Chapter 1. Training specifications	1-9	5.5 Aircraft systems and structures: Rotary wing	5-10
Appendix 3 to Chapter 1. Background to the development of Annex 1 — <i>Personnel Licensing</i>	1-13	5.6 Airship systems and structures	5-11
Chapter 2. General recommendations.....	2-1	Chapter 6. Aircraft engineering and maintenance: Engines/Powerplants	6-1
2.1 Accommodation and equipment for classroom-based training (CBT)	2-1	6.1 Introduction	6-1
2.2 Performance evaluation tests.....	2-2	6.2 Training objectives	6-1
		6.3 Piston engines	6-1
		6.4 Propellers	6-4
		6.5 Gas turbine engines.....	6-5
		6.6 Fuel systems.....	6-8
		Chapter 7. Aircraft engineering and maintenance: Avionics — Electrical/Instrument	7-1
PHASE ONE — KNOWLEDGE		7.1 Introduction	7-1
Chapter 3. Civil aviation requirements, laws and regulations.....	3-1	7.2 Training objectives	7-1
3.1 Introduction	3-1	7.3 Maintenance practices and materials	7-1
3.2 Training objectives.....	3-1	7.4 Electrical and electronic fundamentals ...	7-3
3.3 Required knowledge, skills and attitudes .	3-1	7.5 Digital techniques, computers and associated devices	7-8
Chapter 4. Natural science and general principles of aircraft.....	4-1	7.6 Aircraft electrical systems.....	7-11
4.1 Introduction	4-1	7.7 Aircraft instrument systems.....	7-15
4.2 Training objectives.....	4-1		
4.3 Mathematics.....	4-1		

	Page		Page
Chapter 8. Aircraft engineering and maintenance: Avionics — AFCS/Navigation/Radio	8-1	11.3 Basic workshop and maintenance practices: Engine and propeller	11-2
8.1 Introduction	8-1	11.4 Basic workshop and maintenance practices: Engine/Propeller systems/ Components and function testing	11-4
8.2 Training objectives	8-1	11.5 Job/task documentation and control practices	11-4
8.3 Automatic flight control systems (AFCS): Fixed wing	8-1	Appendix 1 to Chapter 11. Practical maintenance skills: Engine and propeller — Facilities, tools and equipment	11-6
8.4 Automatic flight control systems (AFCS): Rotary wing	8-3		
8.5 Aircraft inertial navigation system (INS)	8-4	Chapter 12. Practical maintenance skills: Avionics — Electrical, instrument, autoflight and radio	12-1
8.6 Aircraft radio and radio navigation systems	8-5	12.1 Introduction	12-1
Chapter 9. Human performance	9-1	12.2 Training objectives	12-1
9.1 Introduction	9-1	12.3 Basic workshop and maintenance practices: Avionics — Electrical	12-2
9.2 Maintenance Resource Management (MRM) and Human Factors	9-2	12.4 Basic workshop and maintenance practices: Avionics — Instrument	12-3
9.3 Phase I — Human Factors awareness phase	9-2	12.5 Basic workshop and maintenance practices: Avionics — Autoflight	12-4
9.4 Phase II — Human Factors practice and feedback phase	9-3	12.6 Basic workshop and maintenance practices: Avionics — Radio	12-4
9.5 Phase III — Human Factors continual reinforcement phase	9-3	12.7 Repair, maintenance and function testing of aircraft systems/component — Avionics	12-5
9.6 Training objectives	9-3	12.8 Job/task documentation and control practices	12-6
9.7 Required knowledge, skills and attitudes	9-3	Appendix 1 to Chapter 12. Practical maintenance skills: Avionics — Electrical, instrument, autoflight and radio — Facilities, tools and equipment	12-7
		PHASE TWO — SKILLS	
Chapter 10. Practical maintenance skills: Airframe	10-1		
10.1 Introduction	10-1		
10.2 Training objectives	10-1		
10.3 Basic workshop and maintenance practices: Airframe	10-1		
10.4 Basic workshop and maintenance practices: Repair, maintenance and function testing of aircraft systems/component	10-4		
10.5 Job/task documentation and control practices	10-5		
Appendix 1 to Chapter 10. Practical maintenance skills: Airframe — Facilities, tools and equipment	10-6		
Chapter 11. Practical maintenance skills: Engine and propeller	11-1	PHASE THREE — EXPERIENCE	
11.1 Introduction	11-1	Chapter 13. Applied practical training: Experience	13-1
11.2 Training objectives	11-1	13.1 Introduction	13-1
		13.2 Training objectives	13-1
		13.3 Applied practical line maintenance operations: Airframe/engine/avionics	13-1
		13.4 Applied practical base line maintenance operations: Airframe/engine/avionics	13-2

INTRODUCTION

The responsibilities of an Aircraft Maintenance (Technician/Engineer/Mechanic) (AME) range from line maintenance, day-to-day care and defect rectification to base maintenance (which can include major modification and repair of the aircraft structure or systems). In many approved maintenance organizations (AMOs), the AME supervises the work of teams of less experienced personnel.

For this reason, the syllabi of instruction for the training of AMEs should be developed based on the specifications outlined in Chapters 2 to 14 of this manual. The standard of training recommended in this manual is intended to be sufficient for an individual to qualify for a Licence which complies with Annex 1 — *Personnel Licensing*, and for an individual, if given additional specialized training, to undertake responsibilities in relation to more specialized aircraft systems or equipment.

The duties envisaged for the AME require supervisory and communication skills, diagnostic prowess and a high degree of technical knowledge. The training courses should therefore be structured in such a way as to provide the trainees with sufficient ability to think logically and to apply their knowledge objectively. The courses should also help them develop physical skills that would enable them to carry out each task in a professional manner by using good engineering and maintenance practices. At the same time, it is also important for the trainees to develop a high degree of confidence, competence, initiative, team spirit and

self-reliance so that they can perform well under varying and sometimes trying circumstances.

Many AMEs are licensed personnel holding licences conforming to the specifications contained in Chapter 4 of Annex 1 to the Convention on International Civil Aviation — *Personnel Licensing*. The privileges of a Licence issued in accordance with Annex 1 by a Contracting State are to certify the aircraft or parts of the aircraft as airworthy after an authorized repair, modification or installation of a powerplant, accessory, instrument and/or item of equipment, and to sign a maintenance release. Part 1 of Chapter 6 of Annex 6 — *Operation of Aircraft* requires the same Annex 1 training standards for signatories of maintenance release in an AMO or equivalent system.

The privileges, responsibilities and terminology relating to aircraft maintenance personnel vary between the States. In some cases licences are limited to certain technology groups such as aircraft engines or radios. In other cases the limitation may be on the kind of tasks performed such as minor servicing or base maintenance.

The target audience of this manual are State aviation regulatory bodies which, in turn, may recommend the manual to their aviation training centres for the development of detailed training syllabi. It may also be used by the State as the basis for the approval of aviation training centres and/or their courses.



ACRONYMS AND ABBREVIATIONS

ACARS	ARINC Communication and Reporting System	CVR	Cockpit voice recording system
AD	Airworthiness Directives	DC	Direct current
ADF	Automatic direction finder	DDM	Difference in depth of modulation
ADG	Air driven generator	DG	Directional gyros
ADI	Altitude direction indicator	DME	Distance measuring equipment
AED	Aeronautical Engineering Directorate		
AF	Audio frequency	EADI	Electronic attitude direction indicator
AFC	Automatic frequency control	ECAM	Electronic centralized aircraft monitoring system
AFCS	Automatic flight control system		
AH	Artificial horizon	EFIS	Electronic flight instrument system
AID	Aeronautical Inspection Directorate	EHIS	Electronic horizontal situation indicator
AIP	Aeronautical information publication	EICAS	Engine indicating and crew alerting system
ALU	Arithmetic logic unit		
AM	Amplitude modulation	ELT	Emergency locator transmitter
AME	Aircraft Maintenance (Technician/Engineer/Mechanic)	EMF	Electromotive force
		ESD	Electrostatic sensitive devices
AMM	Aircraft Maintenance Manual	ESI	Engine speed indication
AMO	Approved maintenance organization	ETOPS	Extended range operations by aeroplanes with two turbine power-units
APU	Auxiliary power unit		
ASI	Air speed indicator		
ATA	Air Transport Association (of America)	FADEC	Full authority digital engine control
ATC	Air traffic control	FBW	Fly-by-wire system
AWOPS	All Weather Operations	FDR	Flight data recording system
		FET	Field effect transistors
BCD	Binary coded decimal	FM	Frequency modulation
BDC	Bottom dead centre	FMCW	Frequency modulated carrier wave
BITE	Built-in Test Equipment	FMEP	Friction mean effective pressure
BMEP	Brake mean effective pressure	FMS	Flight management system
BSFC	Brake specific fuel consumption		
		GCU	Generator control unit
CADC	Central air-data computer	GNSS	Global navigation satellite system
CAT	<i>Computer Applications in Training</i>	GPS	Global positioning system
CDFMCW	Constant difference frequency modulated carrier wave	GPU	Ground power units
CDI	Course deviation indicator	GPWS	Ground proximity warning system
CDU	Control display unit	G/S	Glideslope systems
CG	Centre of gravity	GS	Ground speed
CofA	Certificate of Airworthiness		
CofR	Certificate of Registration	HEIU	High energy ignition units
CRM	Crew resource management	HF	High frequency
CRO	Cathode ray oscilloscope	HSI	Horizontal situation indicator
CRT	Cathode ray tube		
CSD	Constant speed drives	IAS	Indicated air speed
		IATA	International Air Transport Association

IC	Inductive capacitive; Integrated circuits	OPAMP	Operational Amplifiers
IDG	Integrated drive generator		
IF	Intermediate frequency	PCU	Power control unit
IFR	Instrument flight rules	PLL	Phrase locked loop
IGFET	Insulated gate FET	PRF	Pulse repetition frequency
ILS	Instrument landing system	PSU	Passenger service unit
IMEP	Indicated mean effective pressure		
INS	Inertial navigation system	RA	Resolution advisory
I/R	Insulation and resistance	RAT	Ram air turbine
IR	Inductive resistive	RBI	Relative bearing indicator
IRS	Inertial reference system	RC	Resistive capacitive
		RCU	Receiver computer unit
JFET	Junction FET	RF	Radio frequency
		RMI	Radio magnetic indicator
KSA	Knowledge, skills and attitude	RNAV	Area navigation
KVAR	Reactive component	RNP	Required Navigation Performance
		RPM	Revolutions per minute
LCD	Liquid crystal display	RVSM	Reduced Vertical Separation Minima
LED	Light emitting diode		
LF	Low frequency	SAE	Society of Automotive Engineers
LOC	Localizer	SAS	Stability augmentation system
LOFT	Line-oriented flight training	SCR	Silicon controlled rectifier
LOP	Lines of position	SRM	Structural repair manual
LSI	Large scale integration	SSB	Single sideband
LWTR	Licence without type rating (an aircraft maintenance licence)	STC	Sensitivity time control
		TAS	True air speed
MAC	Mean aerodynamic chord	TC	Type certification
MAP	Manifold absolute power	TCAS	Traffic Alert and Collision Avoidance System
MAT	Mass/altitude/temperature		
MEL	Minimum equipment list	TDC	Top dead centre
MIG	Metal inert gas arc welding	TDG	<i>TRAINAIR Training Development Guideline</i>
MKR	Marker system		
MLS	Microwave landing system	TIG	Tungsten inert gas arc welding
MMEL	Master minimum equipment list	TMG	<i>TRAINAIR Training Management Guidelines</i>
MMF	Magnomotive force		
MMO	Maximum operating mach number	TOW	Take-off weight (mass)
MNPS	Minimum navigation performance specification	TR	Type rating (on an aircraft maintenance licence)
MOSFET	Metal oxide silicon FET	TRSB	Time referenced scanning beam system
MRH	Main rotor head	TRU	Transformer rectifier unit
MRM	Maintenance resource management	TWT	Travelling wave tube
MSI	Medium scale integration	ULB	Underwater locator beacon
		VCO	Voltage controlled oscillator
NDB	Non-directional radio beacon	VHF	Very high frequency
NGT	Negative going transition	VLF	Very low frequency
NOTAM	Notices to airmen	VLSI	Very large scale integration
		VMO	Maximum operating speed/velocity
OAT	Outside air temperature	VOR	VHF omnidirectional radio range
OBI	Omni-bearing indicator	VSI	Vertical speed indicators
OEU	Operational equipment unit	VSWR	Voltage standing wave meter
ONS	Omega navigation system		

Chapter 1

TRAINING PRINCIPLES

1.1 REGULATORY REQUIREMENTS

1.1.1 The successful application of regulations concerning the safety and regularity of aircraft operation and the achievement of regulatory objectives depend greatly on the appreciation by all individuals concerned of the risks involved and on a full understanding of the regulations. This can only be achieved by well-planned and well-maintained initial and recurrent training programmes for all persons involved in aircraft operations. Aircraft maintenance personnel play a significant role in the safe operation of an aircraft, and the Annexes to the Convention on International Civil Aviation require that they be appropriately trained.

1.1.2 Paragraph 8.1.2 of Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes* and paragraph 6.1.2 of Annex 6, Part III — *International Operations — Helicopters*, Section 2 require that an operator may only operate aeroplanes which have been maintained and released to service by an approved maintenance organization (AMO) or under an equivalent system acceptable to the State of Registry.

1.1.3 Paragraph 8.1.3 of Annex 6, Part I requires that when the State of Registry of the aircraft accepts an equivalent system, the person signing the maintenance release shall be licensed in accordance with Annex 1 — *Personnel Licensing*.

1.1.4 Paragraph 8.7.5.3 of Annex 6, Part I requires that within an AMO, the competence of maintenance personnel shall be established in accordance with a procedure and to a level acceptable to the State granting the approval. In addition, this paragraph requires that the person signing the maintenance release shall be qualified in accordance with Annex 1. There are however no Annex 1 requirements for personnel who perform the actual maintenance or repair work on the aircraft or its components.

1.1.5 Paragraphs 8.1 and 8.2 of Annex 6, Part II — *International General Aviation — Aeroplanes* require that for general aviation, the person signing the maintenance release shall be qualified in accordance with Annex 1.

1.1.6 The requirements in respect of age, knowledge, experience, training and skills for the licensing of the Aircraft Maintenance (Technician/Engineer/Mechanic) (AME) when employed in conjunction with a method accepted as an equivalent system by the State of Registry for the purpose of signing a maintenance release in accordance with Annex 6, Part I, 8.1.2, are detailed in Annex 1 — *Personnel Licensing*. States use Annex 1 and Annex 6 specifications as a basis for their national regulations that are related to the licensing of aircraft maintenance personnel (technician/engineer/mechanic) and to the approval of operators' maintenance control arrangements in the context of the issue and extension of an Air Operator's Certificate.

1.1.7 Before 1998, Annex 1 categorized licences as Type 1 or Type 2, making a clear distinction between overhaul and release to service. Today Annex 1 no longer specifies these two levels of licence and so States are now able to define the scope of licences in a way that best suits their local needs. The historical background detailing the changes to Annex 1 is shown in Appendix 3 to this chapter.

1.2 TRAINING REQUIREMENTS

1.2.1 States and maintenance organizations may use the training specifications in this manual as part of their training requirements to establish the competence of maintenance personnel, both licensed or unlicensed.

1.2.2 The responsibilities of the AME as specified in Annex 6, Part I are:

- a) signing a maintenance release to certify that the maintenance work performed has been completed satisfactorily and in accordance with the procedures described in the maintenance organization's procedure manual; and
- b) ensuring that the maintenance release contains a certification which includes the details of the work, the date and identity of the organization and the signatory.

1.2.3 In order to sign the maintenance release or certify an aircraft as airworthy, the AMEs must supervise or perform inspections, repairs, replacements, modifications, overhauls and maintenance in such a way that they are able to take responsibility for the work and also issue a maintenance release on completion.

1.2.4 Licensed or unlicensed, AMEs usually specialize in a particular category or categories (e.g. airframes; engines; propellers; aircraft; airships; electrical; instruments or radio systems). The method of performing specific duties may vary according to the type and make of aircraft; the duties and detailed tasks described in this paragraph represent typical examples of those performed by AMEs specializing in the airframe category. It must be understood that the work of other categories may vary quite considerably from that of an airframe category technician. The following paragraphs are a general description of the types of tasks which are performed under the supervision of a licensed AME:

- a) Responds to defects found and recorded by flight crew. Inspects and checks condition of aircraft parts (e.g. engines, wings, tail, fuselage and landing gear) for serviceability by visually inspecting the skin and noting condition of landing gear parts, leaking connections, correct fitting of parts and of operating controls. Attends to all other factors which can affect the safe operation of an aircraft. Determines whether adjustment, repair or replacement is necessary; and if necessary, makes adjustments to manufacturer's/company's maintenance schedule and to the instructions on use of appropriate equipment.
- b) When required to rectify a defect or to meet the Approved Maintenance Programme, ensures the removal and replacement of parts as well as the opening of inspection panels in structure in order to inspect or disconnect control cables, fuel lines and electrical wiring. Determines when and how to support the aircraft on jacks in order to remove and

replace major assemblies such as landing gear or powerplants from the aircraft.

- c) Ensures that adjustments and repairs are carried out as required; e.g. the replacement of cracked material in metal skin surfaces by cutting a new metal patch in accordance with the structural repair manuals from the Type Certificate holder. Reads engineering drawings in order to ensure that structural members are repaired to an approved standard in accordance with manufacturer's instructions.
- d) Supervises the performance of servicing activities such as oleo and tyre inflation, fuel/oil replenishment and lubrication; cleaning of structure and mechanical components; and replacement of light filaments. In accordance with the Type Certificate holder's instructions, a wide variety of test equipment, hand and other tools are used for these tasks.
- e) Writes reports and work details for the maintenance release as required by the operator, the AMO, and Parts I, II and III of Annex 6.

1.2.5 The working environment for maintenance personnel may be noisy due to the operation of power tools, running of engines or manoeuvring of aircraft. The work is sometimes performed in narrow spaces within the aircraft or from ladders or platforms while working on flight surfaces such as wings or fuselages. Sometimes lighting and weather may be poor so good judgement is needed to ensure that the work is not adversely affected. Maintenance personnel may work alone, or more often with a team of aircraft maintenance technicians (both licensed and unlicensed) inside a hangar or workshop or outside on the apron or ramp.

1.3 TYPES OF TRAINING

1.3.1 The training of AMEs requires the imparting of manual and intellectual skills, sound knowledge of basic theory, and a comprehensive understanding of the aircraft or system upon which they will have to work. They should also develop an appreciation for the high value of, and therefore treat accordingly, the aircraft, test equipment and tools that they will use in their work. Trainees should be instructed and encouraged to develop safe and neat working routines as well as a sense of responsibility, technical honesty and integrity. These are essential features since, notwithstanding the inspections carried out during

maintenance, it is these routines and the integrity of the technicians which in many instances will determine the airworthiness of an aircraft.

1.3.2 Practical training is necessarily dependent on the trainees' familiarity with certain background subjects, such as mathematics, physics and technical drawing. The trainees also need to know not only the importance of using the maintenance manuals but also to understand the language and structure of the documents. These manuals have elaborate amendment arrangements, which must also be understood.

1.3.3 The training specifications recommended in this manual are drawn up for practical and on-the-job training phases in classrooms and workshops. The specifications and phase recommendations in this manual assume that the trainee selection, training school management, organization, staffing and facilities generally follow the recommendations of the *Manual on Establishment and Operation of Aviation Training Centres* (Doc 9401).

1.3.4 The training specifications in this manual are presented in such a way that the diverse training needs of AMEs, both in terms of technology and levels of work, can be covered. The recent amendments to Annex 1 now enable the State to issue Aircraft Maintenance Licences in which the scope is limited or categorized in various different ways.

1.3.5 The *Manual of Procedures for Establishment and Management of a State's Personnel Licensing System* (Doc 9379) suggests that the AME privileges outlined in Annex 1 can be categorized technically as follows:

- aircraft in its entirety, specifically or under broad categories
- airframe or powerplant aircraft in its entirety, specifically or under broad categories
- aircraft systems or components, specifically or under broad categories
- avionics systems or components, specifically or under broad categories

Following the practices of many States, Doc 9379 also suggests that the AME privileges can be categorized by scope or kind of work into the following:

- Line Maintenance
- Base Maintenance

Some States are also known to issue AME Licences with or without aircraft release to service privileges. Doc 9379 identifies this as a viable practice (provided appropriate type training for authorization purposes is approved by the State) and suggests the following categorization:

- Type-rated licence (TR) with release to service privileges; and
- Non-type rated licence (LWTR) without release to service privileges.

1.3.6 Table A1-1 in Appendix 1 to Chapter 1 shows how the State may combine or separate the various technical groupings, types of work or licence categories, while ensuring that the licence meets the requirements of Annex 1.

1.3.7 In order to facilitate the States in their selection of the categories and modules that are consistent with the definition of the scope and privileges of their licences, the training specifications in this manual are set out under the same headings contained in Annex 1, 4.2.

1.3.8 Annex 1 does not address the question of different entry qualifications or capabilities. For the training specifications in this manual, it is assumed that the trainees are intelligent, well-motivated, capable of sustained hard work and have a minimum educational attainment equivalent to a good secondary or high school standard, preferably with concentration in the sciences and mathematics. In some States, holders of higher academic qualifications (such as a university degree) in relevant subjects are granted partial exemptions from parts of the syllabus. Aviation training by the military should also be given favourable consideration for appropriate exemptions. It is thus suggested that the State may agree to changes in the syllabus in order to take into account the trainees' entry standards which are significantly different from those described here.

1.3.9 To cover the requirements of Annex 1 and to minimize the cost of rectifying mistakes on airworthy aircraft or components, it is recommended that the training course be divided into the following three phases:

Phase One — Knowledge

Consists of basic training, its completion ensures that a trainee has the necessary background in terms of knowledge to proceed to Phase Two of the training. The training specifications defined in Chapters 3 to 9 are basic principles corresponding to the knowledge common to all the tasks of an AME job.

Phase Two — Skills

Consists of general maintenance practices, practical skills and attitude training in order to master essential skills before proceeding to work on airworthy aircraft or components. A training specification for this phase is detailed in Chapters 10, 11 and 12.

Phase Three — Experience

Consists of applied practical on-the-job training (simulated or actual tasks under supervision) and job-oriented maintenance experience. This phase may be arranged on the job or in the training centre. A training specification for this phase is detailed in Chapter 13.

1.3.10 In practice it will be advantageous to combine Phase One and Phase Two so that the practical aspects can be linked directly to the theory and performed as such, perhaps on the same day or the same week so that the trainees can have a better understanding of the topic. Conversely, there are disadvantages in combining Phase Two and Phase Three. For example, it can be costly to rectify errors of skill on a real airworthy aircraft or its components as compared to the relatively low raw material cost associated with an error made on a bench exercise.

1.3.11 Appendix 2 to Chapter 1 provides an approximate duration for each phase of the training. The duration does not take into account the different entry level capabilities of the trainees. These capabilities are likely to be different in various States and judgements will have to be made in order to avoid trainees repeating same topics. For similar reasons, the duration does not take into account the trainees' level of competency in the language of instruction.

1.3.12 In some cases trainees may have military experience or perhaps an Annex 1 compliant licence from another State. In order to avoid duplication of training and examinations, some States operate a system of credits. Each case is likely to be different and some guidance can be found in Doc 9379.

1.3.13 In using the training specifications recommended in the following chapters, local considerations may dictate the advisability of changing the sequence of the subjects. However, the relative importance accorded to each subject should, as much as possible, remain unchanged. The multiplicity in the types of aircraft, avionic systems and maintenance practices throughout the world makes it undesirable for this manual to define too rigidly many of the headings for the training. Some flexibility must therefore be left to either the State or the training management. The training centres must however ensure that all subjects in their training syllabi are

adequately covered and any requirements relevant to individual regulatory authorities should be treated as additional subjects and not as substitutions for the subjects recommended in this manual. In cases where the training centre and its aviation courses are approved by the State, all subjects required in the State's licensing examination must be adequately covered. Inclusion of any additional topics will have to be made through specific requests by operators and maintenance organizations, depending on the aircraft used in the State.

1.3.14 Visits to aircraft maintenance hangars, workshops and manufacturers' plants are important in order to demonstrate practical application of theory and practice. The interdependence of AMEs with pilots and other technical crew members should be explained by citing examples and bringing them frequently to the attention of trainees.

1.3.15 Physical (motor) skills are a vital feature in the training of AMEs. Training in workshop practice should begin with the use of hand tools to make simple shapes from metal to specified dimensions, followed by more and more complicated and precise tasks. Instructors should ensure that students develop the habit of handling basic tools in the correct manner, and action should be taken to correct any bad or potentially dangerous practices before they become habitual. At all times, and particularly during the early stages of training, the importance of producing accurate and careful work must be stressed. It is better if classroom and workshop activities (Phase One and Phase Two of the training specifications) are integrated so as to demonstrate the practical application of theory.

1.3.16 Attitudes and responsibility are important and emphasis should always be placed on the following:

- a) the responsibility for the safety of co-workers and of the general public;
- b) the individual responsibility of the AME for the quality of work performed;
- c) the importance of good judgement based on positive knowledge and careful analysis of facts;
- d) the importance of asking for help when in doubt;
- e) the importance of continuous study to improve knowledge and keep abreast of both technology and techniques;
- f) the need to adhere to standard procedures and to establish the prevailing procedures;

- g) the need for integrity in all technical matters;
- h) the importance of good teamwork and communication; and
- i) attention to detail and ability to understand written and oral maintenance procedures.

1.3.17 The training course for AMEs should be designed to equip the students with the following essential capabilities that will enable them to pass the State AME licence examinations:

- a) theoretical and practical skills, technical knowledge and attitudes;
- b) familiarization with the design, construction and operation of the types of aircraft and associated equipment (including test equipment) that are in general use in the country where the trainees will work after completion of training; and
- c) inspection ability, i.e. the necessary judgement and sense of responsibility required to assess the airworthiness of aircraft and airborne equipment.

1.4 STANDARD OF ACCOMPLISHMENT

1.4.1 The training of AMEs should be directed towards achieving a standard of competence in which the AMEs are capable of performing their duties safely and with minimum supervision. Recognition of this achievement should be in the form of an official document, perhaps accredited at a national level. Aviation training centres should therefore consider introducing their own diplomas and awards, or make provision for graduating students to obtain the recognized qualifications or licences for their profession.

1.4.2 Training of AMEs in line with the standards of Annex 1 is aimed at ensuring that the required level of professional skills and competence is maintained across international boundaries at a consistently high standard.

1.4.3 Each chapter of this manual describes the training objectives with reference to the required *conditions*, *performance* and a *standard of accomplishment*.

- a) The *conditions* describe the scenario under which trainee performance will be developed and tested, while also indicating whether or not actual equipment, mock-ups, simulators, etc. are to be used.

- b) The *standard of accomplishment* establishes the level of trainee performance that must be attained.

- c) There are two kinds of *standards of accomplishment*, both of which should be tested. The “process” standard indicates the behaviour of the trainee when executing the required performance. Attitude is part of the process standard. Meanwhile, the “product” standard indicates what the product of the required performance looks like.

1.4.4 In measuring the standard of accomplishment, it is recommended that only two grades, PASS and FAIL, be used. For the many training establishments that prefer to use a numerical grading/scoring system, it is possible to assign a numeric grade/score preferred by the establishment (e.g. 70 per cent) to PASS based on the standard (minimum) indicated in the training objective. This way, the numeric grade/score indicates not only a PASS but also shows that the trainee has worked towards a score better than a PASS. A score less than the assigned numeric grade/score of PASS is therefore a FAIL.

1.4.5 The level of accomplishment that must be attained upon the completion of each training unit or module should be determined by the Aviation training centre based on the assessment of a test. The test must be administered according to the standard of accomplishment stated in each chapter of the training specifications in this manual.

1.4.6 This manual also includes some elements of supervisory/management training as this will form an important aspect of the AME job in an AMO or operator. Both Annex 1 and Annex 6 include a requirement for training in Human Factors; this requirement is also included as part of the recommended training specifications.

1.5 TRAINING REFERENCE GUIDE

1.5.1 Appendix 2 to Chapter 1 presents a list of the various subjects and the recommended duration (in hours) that have to be covered during Phase One (Knowledge) and also during Phase Two and Phase Three (Skills and Experience) of training. In appreciation of the fact that differences in State or operator requirements may necessitate changes in the recommended syllabus in order to allow for completion of the course within the period allotted for training, the total number of hours required for the completion of a subject is given.

1.5.2 The training centre should ensure, perhaps by progress tests, that all trainees have achieved the required level in all sections of the syllabus before they are assigned to Phase Three training.

1.5.3 It will be advantageous for the development of the students that Phase One and Phase Two are combined so that the practical aspects can be linked directly to the theoretical aspects. There are also potential economic and equipment utilization benefits for the training centre to combine these two phases.

1.5.4 The various subjects in the training specifications have been assigned codes of 1 to 3 to indicate the increasing level of capability. This classification is included in the manual in order to explain the level required for mastering the knowledge, skills and attitudes of the subject.

<i>Code</i>	<i>Level of capability/requirements</i>
1	denotes a basic understanding of a subject. Trainees should have a basic understanding of the subject but are not expected to be able to apply it in practice.
2	denotes understanding of the subject and the ability, where applicable, to apply it in practice with the help of reference materials and instructions.
3	denotes a thorough understanding of the subject and the ability to apply it with speed, accuracy and judgement appropriate to the circumstances.

1.5.5 Practical workshop training should begin with the use of hand tools to make simple shapes from metal to specified dimensions, followed by more and more complicated and precise tasks in line with the considerations stated in 1.3.15.

1.6 TRAINING OBJECTIVES

1.6.1 Annex 1 and Annex 6 have two requirements affecting aircraft maintenance personnel and which can be met by means of training. These are:

- Annex 1, Chapter 4, which concerns the issue of an aircraft maintenance licence compliant with Annex 1.
- Annex 6, Part I, 8.7.5.3, which requires that within an AMO, “the competence of maintenance personnel (should) be established with a procedure and to a level acceptable to the State granting the approval.”

1.6.2 When designing courses and associated syllabi in order to enable individuals and AMOs to meet the training requirements of Annex 1, an aviation training centre should have the following goals in mind:

- to train an individual to enable him or her to meet the standard required for the issue of an AME licence by the State or its aviation regulatory body;
- to train AMO maintenance personnel to meet the standard of competence required by Annex 1 for signatories of maintenance release; and
- to train AMO maintenance personnel to meet the standard of competence required by that AMO and is approved by the State or its aviation regulatory body.

1.6.3 Many aviation training centres use different standards in training maintenance personnel for all operators or AMOs. While their training courses are not the subject of this manual, it is hoped that the use of training specifications outlined in this manual will enable individuals to gradually achieve the goals cited in 1.6.2.



Appendix 1 to Chapter 1

RECOMMENDED LICENCE CATEGORIZATION AND LIMITATIONS

Table A1-1 illustrates how a State may utilize the various topics in the training specifications of this manual in order to determine the qualifications on basic (rather than aircraft type) topics that should be included in the aircraft maintenance licence categories or subcategories. The table assumes that the State licence scope is divided into either

line or base maintenance as recommended by Doc 9379 — *Manual of Procedures for Establishment and Management of a State's Personnel Licensing System*.

Applicable subjects are indicated by an “L” or a “B” for Line or Base maintenance, respectively.

Table A1-1. Classification of basic topics

Chapter and paragraph	Line (L) or Base (B) Maintenance				
	Aeroplane/Airship		Rotary wing		Avionics
	Turbine engine(s)	Piston engine(s)	Turbine engine(s)	Piston engine(s)	
Chapter 3, all paragraphs	L and B	L and B	L and B	L and B	L and B
Chapter 4, 4.3 to 4.6	L and B	L and B	L and B	L and B	L and B
Chapter 4, 4.7	L and B	L and B			
Chapter 4, 4.8			L and B	L and B	
Chapter 5, 5.3	L and B	L and B	L and B	L and B	
Chapter 5, 5.4	L and B	L and B			
Chapter 5, 5.5			L and B	L and B	
Chapter 5, 5.6	L and B	L and B			L and B
Chapter 6, 6.3		L and B		L and B	
Chapter 6, 6.4	L and B	L and B			
Chapter 6, 6.5	L and B		L and B		
Chapter 6, 6.6	L and B	L and B	L and B	L and B	
Chapter 7, all paragraphs					L and B
Chapter 8, 8.3					L and B

Chapter 8, 8.4					L and B
Chapter 8, 8.5					L and B
Chapter 8, 8.6					L and B
Chapter 9, all paragraphs	L and B	L and B	L and B	L and B	L and B
Chapter 10, all paragraphs	L and B	L and B	L and B	L and B	
Chapter 11, all paragraphs	L and B	L and B	L and B	L and B	
Chapter 12, all paragraphs					L and B
Chapter 13, 13.3 Airframe	L	L	L	L	
Chapter 13, 13.3 Engine	L	L	L	L	
Chapter 13, 13.3 Avionics					L
Chapter 13, 13.4 Airframe	B	B	B	B	
Chapter 13, 13.4 Engine	B	B	B	B	
Chapter 13, 13.4 Avionics					B

Copyright International Civil Aviation Organization

Appendix 2 to Chapter 1

TRAINING SPECIFICATIONS

Table A2-1. Recommended duration and level of capability for Phase One — Knowledge training

Note 1.— This table assumes that the State licence scope is divided into either line or base maintenance as recommended by Doc 9379 — Manual of Procedures for Establishment and Management of a State's Personnel Licensing System. If the State licence combines both line and base maintenance privileges, then the target level of capability should be the higher of the two shown here.

Note 2.— The definition of levels of capability is shown in 1.5.3.

Subject matter	Recommended duration (hours)	Level of capability	
		Line	Base
Chapter 3 Civil aviation requirements, laws and regulations			
3.3.1 International and State aviation law	10	3	2
3.3.2 Airworthiness requirements	10	3	2
3.3.3 Civil aviation operating regulations	10	3	2
3.3.4 Air transport operations	10	3	2
3.3.5 Organization and management of the operator	10	3	2
3.3.6 Operator economics related to maintenance	10	3	2
3.3.7 Approved maintenance organizations (AMOs)	30	3	3
3.3.8 Aircraft maintenance licence requirements	20	3	3
3.3.9 The role of the State aviation regulatory body	10	3	2
3.3.10 Aircraft certification, documents and maintenance	10	3	2
Chapter 4 Natural science and general principles of aircraft			
4.3 Mathematics	75	1	1
4.4 Physics	70	1	1
4.5 Technical drawing	70	1	1
4.6 Chemistry	30	1	1
4.7 Fixed wing aerodynamics and flight control	100	2	2

Subject matter	Recommended duration (hours)	Level of capability	
		Line	Base
4.8 Rotary wing aerodynamics and flight control	100	2	2
Chapter 5 Aircraft engineering and maintenance: Airframe			
5.3 Maintenance practices and materials: Airframe/Powerplant	200	3	3
5.4 Aircraft systems and structures: Fixed wing	250	3	3
5.5 Aircraft systems and structures: Rotary wing	250	3	3
5.6 Airship systems and structures	100	3	3
Chapter 6 Aircraft engineering and maintenance: Engines/Powerplants			
6.3 Piston engines	250	3	3
6.4 Propellers	100	3	3
6.5 Gas turbine engines	300	3	3
6.6 Fuel systems	100	3	3
Chapter 7 Aircraft engineering and maintenance: Avionics — Electrical and instrument			
7.3 Maintenance practices and materials	200	3	3
7.4 Electrical and electronic fundamentals	450	2	2
7.5 Digital techniques, computers and associated devices	200	2	2
7.6 Aircraft electrical systems	250	3	2
7.7 Aircraft instrument systems	250	3	2
Chapter 8 Aircraft engineering and maintenance: Avionics — AFCS/Navigation/Radio			
8.3 Automatic flight control systems (AFCS): Fixed wing	200	3	2
8.4 Automatic flight control systems (AFCS): Rotary wing	75	3	2
8.5 Aircraft inertial navigation systems (INS)	60	3	2
8.6 Aircraft radio and radio navigation systems	450	3	2
Chapter 9 Human performance and limitations			
9.7 Required knowledge, skills and attitudes			
A. General programme overview	3	3	3
B. Human Factors knowledge	3	3	3
C. Communication skills	3	3	3
D. Teamwork skills	3	3	3
E. Performance management	3	3	3
F. Situation awareness	3	3	3

Subject matter	Recommended duration (hours)	Level of capability	
		Line	Base
G. Human error	3	3	3
H. Reporting and investigating errors	3	3	3
I. Monitoring and auditing	3	3	3
J. Document design	3	3	3

Table A2-2. Recommended duration and level of capability for Phase Two — Skills training

Note 1.— This table assumes that the State licence scope is divided into either line or base maintenance as recommended by Doc 9379 — Manual of Procedures for Establishment and Management of a State's Personnel Licensing System. If the State licence combines both line and base maintenance privileges, then the target level of capability should be the higher of the two shown here.

Note 2.— The definition of levels of capability is shown in 1.5.3.

Subject matter		Recommended duration (hours)	Level of capability	
			Line	Base
Chapter 10 Practical maintenance skills: Airframe				
10.3	Basic workshop and maintenance practices: Airframe	725	3	3
10.4	Basic workshop and maintenance practices: Repair, maintenance and function testing of aircraft systems/component	1 000	3	2
10.5	Job/task documentation and control practices	100	3	2
Chapter 11 Practical maintenance skills: Engine and propeller				
11.3	Basic workshop and maintenance practices: Engine and Propeller	450	3	3
11.4	Basic workshop and maintenance practices: Engine/Propeller Systems/Component and Function Testing	450	3	2
11.5	Job/task documentation and control practices	100	3	2
Chapter 12 Practical maintenance skills: Avionics — Electrical, instruments, autoflight and radio				
12.3	Basic workshop and maintenance practices: Avionics — Electrical	775	2	3
12.4	Basic workshop and maintenance practices: Avionics — Instrument	1 000	2	3
12.5	Basic workshop and maintenance practices: Avionics — Autoflight	225	2	3
12.6	Basic workshop and maintenance practices: Avionics — Radio	875	2	3
12.7	Repair, maintenance and function testing of aircraft systems/component: Avionics	100	2	3
12.8	Job/task documentation and control practices	100	3	2

Table A2-3. Recommended duration and level of capability for Phase Three — Experience training

Note 1.— This table assumes that the State licence scope is divided into either line or base maintenance as recommended by Doc 9379 — Manual of Procedures for Establishment and Management of a State's Personnel Licensing System. If the State licence combines both line and base maintenance privileges, then the target level of capability should be the higher of the two shown here.

Note 2.— The recommended duration shown in this table is the period required by Annex 1, 4.2 and assumes that the person has completed a training course approved by the State.

Note 3.— The definition of levels of capability is shown in 1.5.3.

Subject matter	Recommended duration (hours)	Level of capability	
		Line	Base
Chapter 13 Applied practical training: Experience			
13.3 Applied practical line maintenance operations: Airframe	2 years	3	
13.3 Applied practical line maintenance operations: Engine	2 years	3	
13.3 Applied practical line maintenance operations: Avionics	2 years	3	
13.4 Applied practical base maintenance operations: Airframe	2 years		2
13.4 Applied practical base maintenance operations: Engine	2 years		2
13.4 Applied practical base maintenance operations: Avionics	2 years		2

Appendix 3 To Chapter 1

BACKGROUND TO THE DEVELOPMENT OF ANNEX 1 — *PERSONNEL LICENSING*

1.1 Historically Aircraft Maintenance Licence and its privileges have often been deliberated at various meetings of ICAO staff and study groups on Personnel Licensing, which included representatives from Contracting States. As a result numerous changes have been made to Annex 1 since its inception in 1948. A key issue has been the separation of standards and privileges. For many years, licences were classified into Type I (essentially an airworthiness certification of parts after overhaul) and Type II (which held release to service privileges for the complete aircraft). The development of this licensing issue and others is described in various reports of related meetings on file in ICAO.

1.2 In 1952 it was agreed that airlines needed to have Type II licensed Aircraft Maintenance (Technicians/Engineers/Mechanics) (AMEs) who are authorized to issue a maintenance release (Certificate of Safety for Flight). It was also agreed that Type II AMEs in the field should be able to release an aircraft for flight after inspection for possible damage affecting the airworthiness of the aircraft.

1.3 Type I licence privileges were restricted to the certification of parts of the aircraft that were affected by the work performed in overhaul bases and in manufacturing plants. The issue of a maintenance release (Certificate of Safety for Flight) remained a privilege of the Type II licence. Meanwhile, it was agreed that as an alternative, it should be possible for Contracting States to grant the privileges of a licence holder to an approved maintenance organization (AMO).

1.4 As a result, the following definitions were inserted in Annex 1:

- a) To issue a maintenance release (Certificate of Safety for Flight) means to certify that the inspection and maintenance work has been completed

satisfactorily in accordance with the methods prescribed in the Aircraft Maintenance Manual.

- b) To certify as airworthy means to certify that an aircraft or parts thereof comply with current airworthiness requirements after being overhauled, repaired, modified or installed.

1.5 In 1970, the question of Type I and Type II privileges again came under review. As a result, amendments were made to Annex 1 requiring States to indicate separately the privileges attached to licences rated for the aircraft in its entirety and to licences rated for specific components.

1.6 It was further agreed that as Type I licences were being issued to cater to the needs of small operators and owners of General Aviation aircraft and that most States had introduced a system of approved organizations for air carrier aircraft, powerplants and their equipment including avionics, the privileges were amended suitably to incorporate the concept agreed upon for the granting of Type II licences, namely: “to authorize the holder of a restricted licence to certify as airworthy after overhaul, authorized repair or authorized modification of such parts as are entered in his licence and to indicate separately the privileges attached to licences rated for specific components.” In recognition of the practice of successive specialized technician releases, the expression “issuing a maintenance release” was replaced by the defined expression “signing a maintenance release.” This was still the case in 2002.

1.7 These changes to requirements resulted in more diversified training of AMEs. Training courses for Type I or Type II AMEs were common, as were courses for AMEs who did not seek a licence but were being trained to

become part of the team of skilled people (often specialists in one or another aircraft part only) who in turn formed the technical staff of AMOs.

1.8 In 1989 it was recognized that AME licensing practices in many Contracting States had rendered the concept of the Type I licence obsolete as maintenance on large aircraft was generally carried out in AMOs. There was therefore an agreement that a single level of licence broadly based on the Type II licence would be appropriate. However, it was recognized that some States would continue to require Type I licences. It was thus agreed that provisions should be worded in such a way that it would be possible for a State to continue to grant Type I privileges.

1.9 In 1993 the Council at the 16th Meeting of its 138th Session (138/16) adopted Amendment 160 to Annex 1 which related to personnel other than flight crew. This amendment did not cover the licensing provisions for AMEs because during its 128th Session, the Air Navigation Commission decided to develop Standards and Recommended Practices (SARPs) in Annex 6 — *Operation of Aircraft* for an AMO. In view of the close association between the AME licence and the AMO, the Air Navigation Commission felt that a system approach was necessary to ensure consistency between the provisions for AME and AMO. It therefore agreed to postpone its review of the AME licence to provide the time necessary to develop SARPs for AMO.

1.10 In 1997 the Air Navigation Commission noted that the high level of specialization involved in the overhaul of modern complex aircraft and components had rendered a generic qualification (such as that provided by the Type I licence) to be impractical in most cases. In

addition, the distinction between major and minor repairs or modifications was an intricate issue. Practices differed from State to State. Actually very few States were known to grant licences with privileges for the entire aircraft at the level of either Type I or Type II licence. Instead, almost all States granted separate licences or licence ratings for airframes and engines, even though the common practice was for individuals to hold both. Accordingly, Amendment 161 to Annex 1, which introduced a single-level licence for the AME, was adopted in 1998.

1.11 Since their initial adoption in the Second Edition of Annex 1 (1948), Annex 1 Standards for the AME Licence have been intended for persons who sign a maintenance release after routine maintenance or who certify an aircraft or an aircraft component airworthy after repair, overhaul or modification. There are no Annex 1 requirements for the personnel who perform the actual maintenance or repair work to be licensed. The review of the Annex 1 AME licensing provisions confirmed that this approach is still valid, and Amendment 161 continues to provide only for inspection and certification privileges.

1.12 During the adoption process for Amendment 161 to Annex 1, it was noted that the change would not prevent States from having broad-based “generalist” (i.e. Type I) licences if they chose to do so. This amendment provides States with the flexibility to issue an AME licence with various levels and scopes of privileges. However, in order to ensure that the privileges granted are clearly defined, a new Standard (Annex 1, 4.2.2.3) requires that the scope of privileges of the licence holder shall be prescribed and recommends that details of the certification privileges shall be documented either by inclusion or reference in each licence.

Chapter 2

GENERAL RECOMMENDATIONS

2.1 ACCOMMODATION AND EQUIPMENT FOR CLASSROOM-BASED TRAINING (CBT)

2.1.1 General

The *TRAINAIR Training Management Guidelines* (TMG), developed by the TRAINAIR Programme, provides detailed information on training support functions, training delivery, administrative support functions, planning and design of training facilities, etc. Another manual, the *TRAINAIR Training Development Guideline* (TDG), details the development methodologies used in the training courses for aviation personnel and also provides guidelines on the training techniques; validation, revision and implementation of courseware; design of tests; post-training evaluation etc. The training specification in this manual is produced based on job/task analysis, so the majority of the material included in the TMG and TDG may not be applied directly to the training of Aircraft Maintenance (Technicians/Engineers/Mechanics) (AMEs). However the aim of both the TMG and TDG is to provide aviation training managers with the tools they need to effectively manage their training organizations. At the same time, the providers of AME training may be able to benefit by utilizing these tools. Both the TMG and TDG contain detailed information on the issues discussed in this chapter.

2.1.2 Classrooms and equipment

2.1.2.1 Opinions differ on the amount of classroom space required for each trainee. The amount of “ideal” space for each adult in a classroom ranges from a low of 1.4 m² to a high of 6.7 m². The reason for the wide range in the “ideal” dimensions is that classroom designers either envision different classroom environments or account for certain spaces within the classroom (such as aisles and front setback) differently.

2.1.2.2 The sizes of classrooms are affected by:

- number of trainees in a class;
- size of trainee workstation;
- class configuration;
- size of aisles; and
- use of media (in particular, projected media and hands-on projects).

Note.— ICAO recommends that the ratio of trainees per instructor be taken into account when planning the classroom size. In order to provide for sufficient supervision and control, a ratio of 1 instructor for every 6 trainees or 2 instructors for every 15 trainees is recommended. In the case of groups of more than 15, separate parallel courses are recommended.

2.1.2.3 The use of media, hands-on experiments and practical workshop practice is an important factor in determining the amount of common space required in a classroom and the associated practical workshop training area. The most commonly used visual media are slides, chalk/marker boards, overhead projectors, video tapes and easels. The use of projection media (slides, overheads, television, etc.) has considerable impact on room size and it is recommended that the distance between the farthest student and the screen should not exceed 6 times the width of the screen.

2.1.2.4 In planning the space requirements for the training of AMEs, training managers must take into consideration the trainee workstations, the area required for practical hands-on workshop training, faculty workstations, and storage area.

2.1.2.5 Trainee workstation space includes the trainee’s work surface, any additional equipment (terminal, audio/visual, etc.), a chair and the space for manoeuvring the chair. The concept of workstation space is important

when measuring rooms for classes containing different numbers of trainees. The total area allowed in a classroom for each trainee varies with the size of the class. An adequate work surface within the workspace is very important. The large amount of reference material used in the training of AMEs requires considerably larger work surfaces than would be provided by the attached writing surface of an auditorium chair.

2.1.2.6 Personal computers can be useful training aids for AMEs. They can communicate verbal and graphic information and can accept verbal as well as manual or tactile responses. Computers may be used for drills, computer-managed instruction, testing and simulations. For detailed information about the use of computers as a training tool, training managers are advised to refer to the TRAINAIR document — *Computer Applications in Training (CAT)*.

2.1.3 The learning environment

2.1.3.1 The key to a good learning environment is the elimination of discomforts and other undesirable characteristics. Ten primary factors have been identified:

- The climate must be comfortable.
- Lighting must be of adequate level for work or viewing.
- Distracting sound must be kept to a minimum.
- Work areas must be aesthetically pleasing.
- Workstations must be comfortable.
- Workspaces must be adequate.
- Work areas must be reasonably clean.
- Training equipment must be adequate.
- Visual media must be visible.
- Audio media must be satisfactorily audible.

2.1.3.2 If any of these factors is unsatisfactory, the result can be distraction from the task at hand, and fatigue can result from the effort required of the trainee to adapt to a poor environment. One of the most widely cited factors contributing to a positive learning environment is the comfort level of workstations, which includes the comfort level of the chair.

2.2 PERFORMANCE EVALUATION TESTS

2.2.1 Performance evaluation tests are an integral part of the training process. Tests should always be prepared with the sole purpose of measuring whether or not the trainees have achieved the training objective. Trainees must always be informed on how they are going to be evaluated so they can orient their efforts. The information must include the conditions that will exist during the test, the performance that is expected from the trainees, the standards of accomplishment that have to be met, and the consequences of an inadequate performance. Trainees must also be informed of the result of their evaluation. It is recommended that both instructors and trainees review the errors on all tests together in order to obtain feedback that may lead to perfect or improved score on the tests.

2.2.2 Time and resource constraints may limit the amount of testing that can be given to attain each objective. However, the criticality of the subject and the performance difficulties that may be encountered should help determine when, how and what performance evaluation should be required. Generally speaking, performance measurement is undertaken to evaluate whether or not courses taught have been understood by the trainees at the desired level:

- Knowledge is best tested by oral or written tests.
- Skills are best tested by performance tests in which the trainee performs the task described in the objective under real or simulated conditions.
- Attitudes are tested by observations of performance or by means of questionnaires.

2.2.3 The validity of a test is the extent to which a test measures what it intended to measure. Validity can be established by ensuring that the conditions, behaviour and standards of the test correspond to those described in the objective.

2.2.4 The reliability of a test is the ability of a test to consistently reproduce the same results when administered to the same groups of students under the same conditions with different instructors/assessors. To ensure that the test is reliable, the score key providing model answers and specific instructions on how the test should be administered is critical. A model answer should give the instructor enough information to establish how closely the trainee has mastered the tested behaviour. These three elements (score key, model answer, and the conditions under which the test has to be administered) provide the basis for determining a PASS or FAIL grade in a consistent manner.

PHASE ONE — KNOWLEDGE

Chapter 3

CIVIL AVIATION REQUIREMENTS, LAWS AND REGULATIONS

3.1 INTRODUCTION

3.1.1 International aircraft operations is governed by the rule of law; since the first flight by a heavier-than-air machine, a number of conventions, regulations, legislation, orders, agreements, etc. have been promulgated among and within States to ensure that flights are operated in a safe and orderly manner. Achievement of safety and regularity in air transportation operations requires that all States accept and implement a common standard of aircraft operations with regards to training, licensing, certification, etc. for international operations. The standardization of operational practices for international services is of fundamental importance in order to prevent costly errors which may be caused by misunderstanding or inexperience. Although this manual and other ICAO manuals address international aircraft operations, the need for standardization is equally applicable to all other aircraft operations.

3.1.2 International and national regulations and air laws are promulgated to ensure safety, regularity and efficiency of international aircraft operations. On the international scene, ICAO, pursuant to the provisions of Article 37 of the Convention on International Civil Aviation, develops and adopts Standards and Recommended Practices or SARPs (Annexes to the Convention) as the minimum requirement for aircraft operations. National regulations are developed on the basis of the SARPs, with some variations to suit the specific requirements of individual States. States may enact legislation that may differ significantly from those enacted in other States. However, international aircraft operations share many regulations, laws and statutes. The syllabus contained in this chapter gives an overview of air law as adopted by ICAO and practised in international aircraft operations.

3.2 TRAINING OBJECTIVES

Conditions: The trainees will be provided with a broad outline of the regulatory requirements that

must be met by an operator engaged in commercial air transport and an outline of regulatory documents that are significant to the Aircraft Maintenance (Engineer/Technician/Mechanic) (AME) (including those on maintenance), and maintenance control concepts that illustrate the application of regulatory requirements as they relate to the responsibilities and work of the AME.

Performance: The trainees will be able to identify the role of international and national aviation regulatory bodies, identify the importance of applicable regulations to aircraft maintenance activities, and describe the application of regulations relating to aircraft maintenance in those areas which fall under the duties and responsibilities of the AME.

Standard of accomplishment:

The regulations and legislation applicable to the described case will be accurately identified. Provisions, practical applications and implementation will also be described to demonstrate understanding of the relevant issues.

3.3 REQUIRED KNOWLEDGE, SKILLS, AND ATTITUDES

3.3.1 International and State aviation laws

- International Civil Aviation Organization (ICAO): formation, structure, functions, obligations and responsibilities
- Review of ICAO Annexes, particularly Annex 1 — *Personnel Licensing*, Annex 6 — *Operation of Aircraft* and Annex 8 — *Airworthiness of Aircraft*

- ICAO specifications applicable to the particular course of study
- National civil aviation regulations
- Government, ministerial and departmental responsibilities for civil aviation within the State
- State competency and licensing regulations for AMEs
- Formalities prescribed by the State: Certificates of Airworthiness (CoA), logbooks, Certificates of Maintenance, maintenance schedules, and Certificates of Approval
- Format of documents, required signatures, conditions for issue of or compliance, and period of validity

3.3.2 Airworthiness requirements

- Design requirements: performance, structural strength, handling, aerodynamics, reliability, system or component performance and reliability, engine types and tests
- Construction requirements: material quality, construction methods, approved manufacturing organizations (AMOs), systems of traceability to source of origin, and quality control/assurance
- Test requirements: structural test programmes, including “safe life”, “fail safe” and “damage tolerant” testing
- Component testing and systems testing
- Flight test schedules and engine test schedules
- Test programmes for special cases (aircraft, systems and components)
- Procedures for the maintenance of continuing airworthiness
- Airworthiness directives (AD): indigenous, foreign, issue dissemination, and action
- Operational requirements: performance scheduling, flight and operations manuals
- Maintenance requirements: use of aircraft maintenance manuals, maintenance schedules, overhaul periods/lives, “on-condition” maintenance programmes and “condition monitoring” programmes
- Responsibilities of licensed aircraft maintenance personnel working in an operator or an AMO

3.3.3 Civil aviation operating regulations

- Regulations concerning aircraft, aircraft operations, safety, and airworthiness requirements
- Personnel licensing, maintenance of competency, approved organizations, and training requirements
- Aircraft and aircraft maintenance documentation

3.3.4 Air transport operations

- Brief historical review of commercial aviation
- Outline of major factors in airline organization and economics
- Description of route network of State concerned

3.3.5 Organization and management of the operator

- Understanding of the air operator’s responsibilities for maintenance and the relationship between the operator’s Maintenance Control Manual and the maintenance organization’s Procedures Manual
- General structure of an airline; functions and organization of various departments; organization of the maintenance department and AMOs; and detailed functions of departments such as Technical, Engineering, Production Engineering, Quality Control/Assurance and Inspection
- Documentation of maintenance: use of aircraft manuals, manufacturer’s bulletins and ADs, preparation and approval of maintenance schedules, job/task cards, worksheets, aircraft/engine logbooks and operator’s technical logbooks
- Operation of inspection and/or quality departments
- Stores organization and procedures
- Planned maintenance work: inspection periods and component lifing, check cycles, rotation of components, and overhaul requirements
- Hangar layout and equipment, and maintenance docks
- Workshop safety, fire prevention and first aid
- Responsibilities of departmental managers
- Management methods: methods study, time and motion study, statistical methods, budgeting and analysis

3.3.6 Operator economics related to maintenance

- Maintenance costs: percentage of operating costs, capital equipment costs, labour, consumable stores, stores inventory, effect of elapsed time on airline costs, man-hours required to complete typical work, and maintenance time overrun penalties
- Relative costs of overhaul by manufacturer or airline
- Component/powerplant leasing
- Planning: analysis of different cyclic systems (progressive and equalized checks, etc.), long-term planning for mixed fleet, balancing work loading, effects of seasonal peaks on work loading, etc.
- Preparation of worksheets and job cards, task time analysis, and task sequencing for optimum down time
- Development engineering: liaison with manufacturers; study of new aircraft types; performance analysis; modifications policy; defect analysis; engineering contributions to improved utilization; reliability programmes; engine trend monitoring and reliability centred maintenance studies
- Labour policy: skills required, training and recruitment, grading and qualifications; salary structures; agreements with trade unions etc.
- State regulations, incentives and discipline, and welfare
- Quality control/assurance: inspection procedures, documents, records, and sampling techniques; psychological aspects of inspection, and duplicate inspections according to international, national and airline standards
- Safety: national requirements for industrial safety, insurance requirements, hazards from hazardous fluids and gases (such as fuel, hydraulic fluid, vapours), mechanical dangers, and protective measures in work areas

3.3.7 Approved maintenance organizations (AMOs)

- Concept of a corporate body, its legal responsibilities and organizational structure
- Group of persons nominated as being responsible for ensuring compliance with approval requirements
- Establishment of the competence of personnel and training of persons signing maintenance release
- Issue of terms of approval by the State

- AMO procedures and procedure manual
- AMO quality assurance or inspection system
- AMO facilities, tools, equipment and working environment
- AMO storage facilities and procedures
- Access to necessary technical data
- Record-keeping and records procedures, and issue of a maintenance release

3.3.8 Aircraft maintenance licence requirements

- Eligibility, age, limits of location, language and fees
- Categories of licence as defined in State requirements
- Knowledge and experience requirements
- Training requirements
- Examination requirements and content and issue of licence document
- Privileges of the licence
- Revocation and suspension procedures by the State

3.3.9 The role of the State aviation regulatory body

- Protection of public interests by establishing the need for and feasibility of air service and ensuring the safety of flight operations conducted within the State
- Regulation of the degree of competition between operators and exercise of control over commercial air operators
- Definition of the requirements for State-owned or State-operated facilities and services
- State authority is normally exercised through the incorporation of civil aviation acts, laws and statutes into the State's legal system. It is also asserted through the establishment of a State Civil Aviation Authority (CAA) which has the power to apply principles set forth in aviation law, develop civil aviation regulations and orders, and establish requirements for the issue of licences, certificates and other instruments of authority deemed necessary for commercial air transport. The State must also inspect all aspects of commercial air transport operations to ensure continuing compliance with State requirements, recommend corrective action to air operators and revoke air operators' licences.

3.3.10 Aircraft certification, documents and maintenance

3.3.10.1 Aircraft, propeller and engine Type Certification

- Certification rules (e.g. FAR/JAR 23, 25, 27 and 29)
- Type Certification (TC), TC issue, and associated TC Data Sheet
- Supplemental Type Certification or major modification

3.3.10.2 Individual aircraft certification

- Approval of design or production organizations
- Issue of Certificate of Airworthiness (CofA) and Certificate of Registration (CofR)
- Documents to be carried on-board the aircraft: CofA, Cof R, Noise Certificate, Weight and Balance Reports, and Radio Station Licence and Approval

3.3.10.3 Requirements for continuing airworthiness

- Understanding of the concept that continuing airworthiness is the process of ensuring that at any time in its operating life, the aircraft should comply with airworthiness requirements and should be in a condition for safe operation

- Renewal or continued validity of the CofA
- State approval or acceptance of maintenance programmes, minimum equipment lists, ADs, manufacturer's service information (SBs, SLs, etc.), aircraft maintenance manual, operator maintenance control manual, and AMO Maintenance Procedures Manual
- Understanding of the importance of defect reporting to the State of Registry and to the organization responsible for the type design
- Analysis of defect accident or other maintenance or operational information by the organization responsible for the type design
- Importance of structural integrity with particular reference to supplemental structural inspection programmes and any other requirements related to ageing aircraft
- Special operational approvals (e.g. Extended Range Operations by Aeroplanes by Twin-engined Aeroplanes (ETOPS), All Weather Operations, Reduced Vertical Separation Minima (RVSM), Required Navigation Performance (RNP), and Minimum Navigation Performance Specifications (MNPS))

Chapter 4

NATURAL SCIENCE AND GENERAL PRINCIPLES OF AIRCRAFT

4.1 INTRODUCTION

4.1.1 In addition to the subjects which are of direct day-to-day concern to the responsibilities of the Aircraft Maintenance (Technician/Engineer/Mechanic) (AME), the AME training should include a sound understanding of the academic aspects of aircraft and aviation operations. This background will provide the trainees with a more complete understanding of not only their working environment but also the wider scientific principles employed in aviation.

4.1.2 The academic level of background subjects such as mathematics and physics should be specified as a prerequisite to course entry. However, if this is not practical or possible, then mathematics and physics may be taught to the required level before the start of the aviation training course. Where the knowledge of mathematics and physics is only just below the required entry level, or it is felt that a refresher course in mathematics and physics would be advantageous to the students, then these subjects could be taught in parallel with the aviation subjects.

4.1.3 The selection of topics for the mathematics and physics syllabi as well as the type of course instruction must reflect the depth and breadth of knowledge required to fully complement the level required by the aviation subjects.

4.1.4 Even though it is covered in the Maintenance Practices and Materials sections of both the mechanical and avionics curricula, technical drawing has been incorporated into the area of natural science and general principles of aircraft for the benefit of those students who will be involved in major modification and/or repair work.

4.1.5 Understanding the subjects of mathematics, physics, technical drawing, etc. constitutes an important part of the AMEs training base. It will permit a more comprehensive operational understanding, develop general in-depth awareness of air transport operations, and improve

communication with both flight crew members and other maintenance personnel, thereby improving the overall safety of the aircraft operation.

4.2 TRAINING OBJECTIVES

Conditions: The trainees will receive instructions on pertinent information on aviation-relevant situations or characteristics.

Performance: The trainees will be able to identify and explain how the conditions relate to the scientific principles by using correct aviation nomenclature and mathematics.

Standard of accomplishment:

The trainees will display a good understanding of the principles, and make required calculations quickly and accurately, while also displaying some understanding of the context of practical applications.

4.3 MATHEMATICS: REQUIRED KNOWLEDGE, SKILLS AND ATTITUDES

4.3.1 Arithmetic

- Arithmetical terms and signs; methods of multiplication and division; fractions and decimals; factors and multiples; weights, measures and conversion factors; ratio and proportion; averages and percentages; areas and volumes; squares, cubes, square and cube roots

4.3.2 Algebra

- Evaluation of simple algebraic expressions; addition, subtraction, multiplication and division; use of brackets; simple algebraic fractions, linear equations and their solutions; and introduction to simultaneous equations
- Polynomials and binomial theorem, solution of second degree equations with one unknown, solution of simultaneous linear equations, and use of complex numbers

4.3.3 Geometry

- Simple geometrical constructions
- Graphical representation: nature and uses of graphs, rectangular and polar coordinates; graphs of equations
- Simple trigonometry: trigonometrical relationships and use of tables

4.3.4 Trigonometry

- Solution of plane triangles; solution of spherical triangles; application of some hyperbolic functions

4.3.5 Logarithms

- Indices and powers: negative and fractional indices; square root; reciprocal and exponential tables
- Logarithms: use of log tables, and logarithms of products, quotients, powers and root

4.3.6 Calculators

- Use of electronic calculators for logarithmic and trigonometric applications

4.3.7 Differential and integral calculus

- Derivatives and differentials; maxima and minima; expansion in series; indeterminate forms; curvatures; table of indefinite integrals, definite integrals; differential equations encountered in physics

4.3.8 Graphical representation of functions

- Equations involving two variables; equations for empirical curves; use of logarithmic paper; equations involving three variables; alignment charts

4.4 PHYSICS: REQUIRED KNOWLEDGE, SKILLS AND ATTITUDES

4.4.1 Mechanics

- Forces as vectors: scalars, vectors, resultants, triangle of vectors, polygon of vectors, and resolution of a vector
- Forces and moments, composition and resolution
- Centre of gravity
- Uniform motion in a straight line; acceleration; motion under gravity; Newton's Laws; momentum; force; mass and weight; work, energy, rate of doing work, potential energy, relative velocity, angular velocity, physical units of mass, force, speed, work and power
- Friction: nature and effects, and coefficient of friction
- Specific gravity and density
- Viscosity, fluid resistance and rolling resistance
- Pressure and buoyancy in liquids (barometers)
- Elements of fluid dynamics: streamlines, Bernoulli's Theorem, venturi, Pitot tube and speed of sound
- Elements of vibration theory: harmonic motion, pendulum, damped harmonic motion, forced harmonic motion, and resonance
- Velocity ratio, mechanical advantage and efficiency
- Elements of theory on stress, strain and elasticity; tension, compression, shear and torsion stress; Hooke's Law and Young's Modulus
- Dynamics: kinematics of pure rotation, work, power, torque, kinetic energy, moment of inertia, radius of gyration, rotational equilibrium, centre of mass, couples, momentum and impulse, conservation of momentum, elastic and inelastic collisions, two-dimensional motion, and rolling bodies
- Elasticity: internal forces in solids, stress, strain, Hooke's Law, Poisson's ratio, shear, torsion, and bulk modulus
- Periodic motion: motion in a circle at constant speed, energy relations in simple harmonic motion, angular harmonic motion, and equilibrium of a dynamical system

4.4.2 Heat

- Temperature: thermometers and temperature scales (Celsius/Centigrade, Fahrenheit, Rankine and Kelvin); conversion from one scale to another
- Expansion: linear expansion, surface and volume expansion
- Quantity of heat: units of heat (calories, BTU, CHU), heat capacity and specific heat
- Heat transfer: convection, radiation and conduction
- Mechanical equivalent of heat, first and second laws of thermodynamics
- Properties of fluids: solid, liquid and gaseous states, melting, boiling, evaporation and reverse processes, vapour pressure, absolute and relative humidity
- Gases: ideal gas; Charles' and Boyle's Laws; internal energy of a gas; specific heat of a gas; relationship between internal energy and heat
- Latent heats of fusion and evaporation, thermal energy, and heat of combustion
- Gases: specific heat at constant volume and constant pressure; work done by expanding gas; kinetic theory of gases
- Avogadro's number
- Thermodynamics: isothermal expansion and compression; adiabatic expansion and compression; the Carnot cycle; engine cycles; constant volume and constant pressure; refrigerators and heat pumps

4.4.3 Light

- Introduction to nature of light; speed of light
- Laws of reflection and refraction: reflection at plane surfaces; reflection by spherical mirrors, refraction, lenses, cameras and projectors, microscopes and telescopes
- Propagation of light, illumination, and photometry
- Wave optics: interference, interferometers, Huygens' model, diffraction, diffraction gratings, and polarization
- Spectra: dispersion by refraction, spectrometers, emission and absorption spectra, and quanta

4.4.4 Electricity and magnetism

- Fundamentals: atoms and electrons, conductors and insulators, electric currents, electromotive force, difference of potential, electrical units, power, work and energy, Ohm's Law, specific resistance, series, parallel and combined DC circuits, Kirchoff's Laws and the Wheatstone Bridge
- Batteries and thermal EMF: theory of electrolysis, primary cells, secondary cells; lead-acid and alkaline accumulators; and thermocouples
- Magnetism: permanent magnets, laws of magnetism, the earth's magnetism, magnetic fields, electro-magnetism, polarity rules, field strength and flux density, permeability, hysteresis, and reluctance
- Electrostatics: positive and negative charges, charges developed by friction, electrostatic induction, surface charges, electrostatic fields, static charges on aircraft and methods of dispersing them
- Electromagnetic induction: Faraday's Laws, Lenz's Law, magnitude and direction of induced EMF, generators, and induction coils
- Inductance and capacitance: mutual inductance; self-inductance; unit of capacitance; specific inductive capacity; dielectric strength; losses and efficiency
- Outline of AC theory: generation, principles, single-phase and three-phase generation, measurement of current and voltage, RMS, audio and radio frequencies
- Resistance, inductance and capacitance in AC circuits: inductive reactance, resistance and inductance in series, impedance, power factor and true power, capacitive reactance, resistance and capacitance in series, resonance, Q factor, and voltage developed at resonance
- Resistance, inductance, capacity and parallel combinations
- Methods of coupling: mutual inductive coupling, resistive coupling, auto-inductive coupling, capacitive coupling, equivalent resistance, equivalent reactance, coupling factor, and resonance curves
- Transformers: primary and secondary EMF; load-on secondary, resistive, inductive and capacitive loads; transformer losses; tests of transformers; X-rays and natural radioactivity; photoelectric and inverse photoelectric effect; generation of X-rays; radioactive substances; radiography with X-rays and gamma-rays

4.4.5 Wave motion and sound

- Wave motion: mechanical waves, sinusoidal wave motion, interference phenomena, and standing waves
- Sound: speed of sound, production of sound, intensity, pitch and quality, and Doppler effect

4.5 TECHNICAL DRAWING: REQUIRED KNOWLEDGE, SKILLS AND ATTITUDES**4.5.1 Introduction**

- Purpose of technical drawing
- Care and use of drawing instruments
- Standard paper sizes, blocks, conventions for lines, and dimensions

4.5.2 Practice with drawing instruments

- Lettering
- Simple geometric constructions
- Layout of patterns with metric or inch dimensions

4.5.3 Simple orthographic projections

- Orthographic conventions
- Practice in first angle projections
- Practice in third angle projections

4.5.4 Simple isometric projections

- Isometric conventions
- Practice in making workshop sketches

4.5.5 Geometric construction

- Constructions involving lines and angles, circles and conic sections
- Geometric projections

4.5.6 Practice in sketching

- Proportioning
- Orthographic sketching
- Pictorial sketching

4.5.7 Orthographic projection

- Rules, determination of number of views, notation and representations, layout of three-view drawings, computation of weights
- Sectional views, standard symbols for sections and materials
- Dimensioning
- Representation of machine elements, threads, bolts, nuts, rivets, etc.
- Exercises incorporating standard conventions

4.5.8 Shop terms and processes

- Relationship between drawing and manufacturing processes
- Drawings for castings, forgings, machined parts, sheet metal parts, and welded constructions
- Practices as appropriate to particular course

4.5.9 Assembly drawings

- Layout drawing
- Assemblies, erection and installation drawings, interchangeability, tolerances, fits and clearances, datum surfaces, tolerancing of form and position
- Surface finish, finish marks and specifications
- Checking drawings

4.5.10 Auxiliary projections

- Notation and relationship of auxiliary planes
- Layout of drawing with one auxiliary view
- Layout of drawing with two auxiliary views

4.5.11 Axonometric projection

- Isometric projections, dimetric and trimetric projections
- Theory of axonometric projections

4.5.12 Oblique projection

- Theory
- Cavalier projection
- Cabinet projection

4.5.13 Circuit layout

- Convention for electrical and radio components
- Standard symbols for theoretical circuits and wiring diagrams

4.5.14 Exercises in blueprint reading

- Interpretation of blueprint data
- Check for consistency

4.5.15 Exercises in engineering design

- To be selected by the instructor in accordance with the nature of the particular course and the type of work that the student will undertake in the future

4.6 CHEMISTRY: REQUIRED KNOWLEDGE, SKILLS AND ATTITUDES

- Nature of matter: the chemical elements; structure of atoms, molecules, crystals, colloids, solutions and solvents; hardness and ductility

4.7 FIXED WING AERODYNAMICS AND FLIGHT CONTROL: REQUIRED KNOWLEDGE, SKILLS AND ATTITUDES

4.7.1 Aerodynamic physics

- Application of International Standard Atmosphere (ISA) to aerodynamics

- Newton's Laws of Motion

- Boyle's Law
- Charles' Law
- General Gas Laws
- Archimedes Principle
- Bernoulli's Theorem
- Dalton's Law

4.7.2 Airflow

- Airflow in relation to a body at rest and in motion
- Boundary layer: laminar and turbulent flow, free stream flow, relative airflow, upwash and downwash, vortices and stagnation
- Effect of ice on an aircraft

4.7.3 Aerofoils

- Understanding of the following terms:
 - camber
 - chord
 - mean aerodynamic chord
 - parasitic drag
 - induced drag
 - centre of pressure
 - angle of attack
 - angle of incidence
 - wash in and wash out
 - fineness ratio
 - wing shape
 - aspect ratio
- Relationship between lift, weight, thrust and drag

4.7.4 Conditions of flight

- Understanding of the following terms:
 - wing loading
 - centrifugal force
 - centripetal force
 - gravitational force
 - sideslip
 - skidding
 - stall
 - centre of gravity



- Effects on wing loading and stalling speed due to changes in wing area, angle of bank, angle of attack, and mass
- Relationship between ground speed (GS), true air speed (TAS) and indicated air speed (IAS)

4.7.5 Flight stability

- Understanding of the following terms:
 - dihedral
 - longitudinal dihedral
 - anhedral
 - sweepback
 - taper
 - torque effect
 - slipstream
 - gyroscopic effect
 - asymmetric power/thrust
 - longitudinal stability
 - lateral stability
 - directional stability
 - flutter
 - Dutch roll
 - pitch up

4.7.6 Flight controls

- Operation and effect of roll control: ailerons and spoilers pitch control; elevators, stabilators, variable incidence stabilizers and canards yaw control; rudders including rudder throw limiters
- Control about two axes, elevons, and ruddervators
- High lift devices, slots, slats, and flaps (including leading edge flaps)
- Drag inducing devices, spoilers, lift dumpers, and speed brakes
- Boundary layer control using wing fences, saw-tooth leading edges, vortex generators, stall wedges or leading edge spoilers
- Operation and effect of trim tabs, balance (lagging) and anti-balance (leading) tabs, servo tabs, spring tabs, bob weights, control surface bias, and aerodynamic balance panels
- Understanding of aerodynamic balance
- Power-assisted and power-operated controls: purpose, layouts, power supplies, artificial feel devices, installation, adjustments and testing

- Fly-by-wire systems (FBW) (both digital and analogue), full FBW system and FBW with manual reversion

4.7.7 High speed flight

- Understanding of the following terms and of the factors which affect them:
 - speed of sound
 - subsonic flight
 - transonic flight
 - supersonic flight
 - mach number
 - critical mach number
 - mach cone
 - compressibility
 - shock wave (oblique and normal)
 - expansion waves
 - shock-induced stall
 - shock-induced drag
 - aerodynamic heating
 - area rule
- Factors affecting airflow in engine intakes of high-speed aircraft
- Effects of sweepback and fineness ratio on critical mach number
- Control problems encountered and methods to overcome them in transonic and supersonic flight

4.8 ROTARY WINGS AERODYNAMICS AND FLIGHT CONTROL: REQUIRED KNOWLEDGE, SKILLS AND ATTITUDES

4.8.1 Introduction

- Classification of helicopter types
- Guide to operating environment peculiar to helicopters
- Names of airframe components of helicopter and function of main components
- Strength and weight of components

4.8.2 Rotary wing theory of flight

- Understanding of the following terms:
 - air density